WEATHER AND COTTON PRODUCTION

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Two main lines of studying the relation of weather to yield of crops have been followed by investigators in several different countries. One involves an effort to establish meteorological cycles, or quasi-regular sequences, comprising a definite number of years, the recurring phases of which are supposed to show meteorological conditions quite similar to their predecessors, with a consequent reproduction of agricultural phenomena. The other has to do with the influence on production of weather during the growing season, and is usually studied by statistical determinations of the relation between weather records and yield. The ultimate goal of all such investigations is to permit a forecast of yield as far as possible in advance of harvest.

The first method has to do with some form or other of long-range forecasting of weather or of yields; that is, a determination a year or more in advance of the kind of weather, and hence yield, that may be expected for a particular season, either from past weather records or from past yield records. Clearly, the establishment of cycles or periods of this character that would give an indication of crop production far in advance, even within rather wide limits of accuracy, would be of the greatest importance. A number of such studies have been made, among which may be mentioned those of Prof. H. L. Moore, Columbia University, and Sir Napier Shaw and Sir William Beveridge, of England; but it appears the difficulty in the application of seemingly significant results lies largely in the bewildering number of weather or yield cycles apparently found.

The second method, which deals with the weather prevailing during plant development, has received the attention of a much greater number of investigators, both in this country and abroad. Various papers on the subject have been published by employees of the Weather Bureau and others from time to time, while in England the relation between weather and crops has formed the subject of the inaugural address of two presidents of the Royal Meteorological Society, Mr. Mawley, in 1898, and Mr. Hooker, 1921. Other investigators include Hall, of England; Wallen, of Sweden; Okada, of Japan; Taylor, of Australia; and Jacob, of India.

In a study of the relation of weather to the yield of crops it is necessary, because of varying weather conditions and yields over an extended area, to adopt a comparatively small geographic unit as a base. In this country unit State areas are usually considered, because considerable weather data and most yield data are normally compiled and published on this basis; otherwise, an enormous amount of labor is required to compile the necessary statistics in convenient form for study. Again, investigations are usually confined to a single State or to only a small part of the production area for a given crop. Such studies are valuable, but they necessarily have limited utility, because of the comparative unimportance of the yield of a single State, or a small area, to that for the country as a whole.

The present paper has to do with the effect of weather on the yield of cotton in the United States, and includes practically the entire producing area. Cotton is one of the most important crops grown in this country, and those interested in production are very much concerned with the prevailing weather during the growing season as affecting the progress of the crop, and providing a "pointer" to probable production. The trade spends large sums of money annually in collecting and studying current meteorological data, and prices from day to day are very sensitive to weather conditions and changes; yet, definite, concrete knowledge of the weather-cotton relation, mathematically determined, has been very meager.

The advent of the boll weevil complicated the study of weather effect on cotton production, because of the varying amount of damage done by this pest from year to year, but it was early recognized that weevil activity is also very largely a weather problem. To be of most value in indicating yield, data as to the causative factors, whether weevil or weather, must be available comparatively early in the season, and as long as possible before harvest. In the present study this desideratum was constantly kept in mind, and it will be noted that practically all requisite data are obtainable early in September for a current growing season.

There are two major influences operating to vary the production of cotton from year to year—weather and the cotton boll weevil. But weevil activity and the corresponding varying damage are dependent very largely on the weather and consequently the whole matter bases, primarily, on weather conditions, operating through a direct effect on production and an indirect effect through weevil ravages. Because of the weevil influence, it was apparent early in this study that the first problem was to establish, if possible, a relation between the weather and weevil activity, whereby this indirect influence could be approximated in season to be utilized simultaneously with weather records in direct relation to production. This was necessary because the weevil data collected by the Department of Agriculture are not available under present practices until long after cotton has been harvested.

Following this avenue of approach a working formula was first devised whereby a weevil index of yield reductions could be obtained long before these data are available by the present methods of compilation. The results, a part of this general investigation, were presented in a paper published in the MONTHLY WEATHER REVIEW for August, 1928, under title "Weather and the Cotton Boll Weevil." Weevil data are available for the 20-year period from 1909 to 1928, inclusive, and these years are included in the present paper. The weevil data used in establishing the basic equations are those reported by the Department of Agriculture, and methods of determining a weevil index from weather data for projection of the various curves, or for application to future years, are explained later in this discussion.

Broadly, we have computed from the relation of weather to yield, as determined by methods of multiple coefficients and regression constants, a set of per-acre yield indices for each of the 10 principal cotton States, representing within a very few per cent the entire cotton production of the country. The per-acre State indices are then combined, by proper weighting on an acreage basis, to form a composite, or average, per-acre yield for the entire belt. This latter, applied to the total acreage, gives, of course, a total production for the belt in pounds, which is finally reduced to standard bales. Reference to the accompanying tables indicates the procedure, as follows:

TABLE 1

NORTH CAROLINA

Year	Yield (lbs. per acre)	Weevil data	Adjusted yield	Weather data (See text description) a	b	c	d	e	f	Computed adjusted yield	Computed yield indices
	1	2	3	4	5	6	7	8	9	10	11
1909	210	0	210	5.4	7.9	67	3.0			226	226
1910	227	0	227	5.0	7.4	62	3.0			222	222
1911	315	0	315	1.3	2.8	70	3.4			311	311
1912	267	0	267	4.6	5.7	69	5.0			254	254
1913	239	0	239	4.4	4.9	65	5.8			254	254
1914	290	0	290	1.4	3.3	69	3.2			302	302
1915	260	0	260	5.6	4.4	72	3.9			285	285
1916	215	0	215	4.6	6.4	57	2.7			228	228
1917	194	0	194	2.8	6.0	54	7.0			207	207
1918	268	0	268	3.6	3.8	60	4.2			267	267
1919	266	0	266	5.3	5.0	61	1.2			265	265
1920	275	0	275	1.8	4.9	64	4.7			259	259
1921	264	4	275	4.5	3.0	64	2.8			294	282
1922	250	13	288	5.1	6.4	63	1.6			247	215
1923	290	13	334	4.3	2.4	66	4.0			302	263
1924	196	7	211	5.3	5.3	65	10.7			222	206
1925	261	8	284	2.8	3.9	69	2.0			307	282
1926	292	3	302	1.7	3.9	70	1.7			303	294
1927	238	16	284	2.5	4.9	68	2.0			281	236
1928	212	12	241	4.8	5.5	67	11.2			221	194
Sum	5,029		5,245	76.8	97.8	1,302	83.1				5,052
Mean	251		262	3.8	4.9	65.1	4.2				253

SOUTH CAROLINA

Year	1	2	3	a	b	c	d	e	f	10	11
1909	210	0	210	12	4.9	73				211	211
1910	216	0	216	13	5.8	76				211	211
1911	280	0	280	8	3.8	74				244	244
1912	209	0	209	9	5.2	73				226	226
1913	235	0	235	12	4.8	74				215	215
1914	255	0	255	8	5.2	78				250	250
1915	215	0	215	9	3.3	76				248	248
1916	160	0	160	11	14.7	74				162	162
1917	208	0	208	8	6.6	70				213	213
1918	250	0	250	7	5.0	70				228	228
1919	240	3	248	10	8.9	74				202	196
1920	260	13	299	6	5.6	81				270	235
1921	140	31	204	6	7.4	74				234	161
1922	123	40	205	11	7.2	73				203	122
1923	187	27	257	8	4.5	78				254	185
1924	160	16	191	10	6.9	70				200	168
1925	160	12	182	8	3.2	57				187	165
1926	182	4	190	8	6.2	73				226	217
1927	148	27	203	13	6.4	74				200	146
1928	147	15	173	12	6.8	78				218	185
Sum	3,985		4,390	189	122.4	1,470					3,988
Mean	199		220	9.5	6.1	74					199

GEORGIA

Year	1	2	3	a	b	c	d	e	f	10	11
1909	184	0	184	80.6	18.5	15.1				172	172
1910	173	0	173	80.6	17.9	16.5				165	165
1911	240	0	240	84.4	21.9	10.3				219	219
1912	159	0	159	83.4	17.4	17.6				170	170
1913	208	0	208	83.7	22.0	12.7				211	211
1914	239	0	239	85.2	22.5	8.9				229	229
1915	189	0	189	85.0	20.4	14.8				201	201
1916	165	3	171	86.2	19.5	21.1				184	178
1917	173	9	191	78.4	21.7	10.8				193	176
1918	190	11	214	84.1	20.1	10.6				207	184
1919	152	19	188	80.6	17.7	19.4				156	126
1920	138	31	200	79.0	20.2	13.9				178	123
1921	90	45	164	80.2	20.7	13.7				186	102
1922	100	44	179	81.0	18.9	17.3				170	95
1923	82	37	131	78.0	17.6	18.4				148	93
1924	157	15	185	79.4	19.6	13.9				176	150
1925	155	7	167	81.2	20.3	8.2				202	188
1926	180	5	190	82.9	19.1	11.4				194	189
1927	154	18	188	84.8	18.4	13.7				192	157
1928	131	14	153	79.8	18.9	17.7				164	141
Sum	3,259		3,713	1,638.5	393.3	286.0					3,269
Mean	163		186	81.9	19.7	14.3					163

TABLE 1—Continued

ALABAMA

Year	Yield (lbs. per acre)	Weevil data	Adjusted yield	Weather data (See text description) a	b	c	d	e	f	Computed adjusted yield	Computed yield indices
	1	2	3	4	5	6	7	8	9	10	11
1909	142	0	142	63.4	6.6	52	4.5			156	156
1910	160	0	160	61.9	3.9	56	7.1			159	159
1911	204	0	204	63.9	2.8	71	5.7			190	190
1912	172	2	176	64.6	3.6	56	5.2			179	175
1913	190	4	198	62.3	3.1	76	5.0			189	181
1914	209	6	223	63.8	1.0	78	4.2			213	200
1915	146	16	174	64.9	6.3	68	5.2			170	143
1916	79	28	110	62.2	4.3	62	16.7			116	84
1917	125	29	177	64.0	2.4	75	6.0			194	138
1918	149	12	170	61.1	2.5	68	3.9			189	166
1919	122	29	172	62.6	6.1	61	6.6			153	109
1920	111	36	174	62.3	4.9	71	5.3			172	110
1921	124	32	183	62.3	2.0	71	5.2			192	131
1922	142	26	192	66.9	6.7	64	4.4			175	129
1923	91	33	136	63.4	8.6	69	5.2			150	100
1924	154	12	175	63.3	4.2	68	3.6			186	164
1925	185	5	195	68.2	2.3	72	4.9			212	201
1926	196	3	203	61.2	3.0	70	6.1			177	172
1927	180	15	212	68.1	2.6	54	4.0			202	172
1928	145	12	165	59.8	3.6	54	5.1			164	144
Sum	3,026		3,541	1,270.2	80.5	1,316	113.9				3,024
Mean	151		177	63.5	4.0	65.8	5.7				151

MISSISSIPPI

Year	1	2	3	a	b	c	d	e	f	10	11
1909	157	4	164	6.8	10.0	6.5	82.0			181	174
1910	182	15	215	3.9	4.9	6.5	79.7			204	173
1911	172	5	182	9.6	2.1	4.5	78.6			188	179
1912	173	18	211	10.3	4.4	5.1	80.7			191	157
1913	204	33	305	5.0	4.2	2.1	81.4			237	159
1914	195	24	257	4.7	1.8	2.3	82.3			264	201
1915	167	25	223	1.1	5.8	4.7	80.8			231	173
1916	125	32	184	3.0	7.4	4.1	80.4			208	141
1917	155	22	199	4.8	1.9	2.8	81.0			246	192
1918	187	10	208	7.8	1.6	3.9	79.7			215	193
1919	160	20	200	5.2	8.0	5.0	81.1			198	158
1920	145	32	214	9.5	5.9	4.5	80.2			181	123
1921	148	30	212	9.4	1.6	2.9	82.4			240	168
1922	157	28	218	5.2	5.9	3.7	80.5			209	150
1923	91	31	132	8.5	9.1	5.2	79.4			154	106
1924	176	7	190	5.0	4.5	3.5	81.2			228	212
1925	275	3	284	1.2	3.8	2.5	82.3			268	260
1926	241	6	257	3.4	3.8	3.3	80.5			234	220
1927	194	16	231	5.1	4.5	5.1	81.7			228	192
1928	176	14	205	8.9	4.3	9.3	81.7			195	168
Sum	3,480		4,291	118.4	95.5	87.5	1,617.6				3,499
Mean	174		215	5.9	4.8	4.4	80.9				175

TENNESSEE

Year	1	2	3	a	b	c	d	e	f	10	11
1909	158	0	158	5.8	57.7	68.8	76.7			168	168
1910	207	0	207	5.2	56.5	64.1	77.0			162	162
1911	257	0	257	1.8	62.0	69.7	76.0			218	218
1912	169	0	169	4.0	60.6	64.4	77.4			192	192
1913	210	0	210	3.9	59.9	67.3	80.0			210	210
1914	200	0	200	2.2	59.1	72.5	79.5			227	227
1915	188	0	188	5.7	60.8	66.6	77.0			180	180
1916	206	1	209	5.1	61.9	65.5	77.9			193	191
1917	130	2	133	3.4	53.2	65.2	76.4			161	158
1918	175	0	175	3.7	62.8	69.2	74.7			197	197
1919	195	0	195	6.5	58.4	70.0	79.2			182	182
1920	185	1	187	4.2	60.2	66.2	76.6			187	185
1921	228	7	246	2.4	60.2	71.2	80.2			232	216
1922	190	9	209	4.8	62.9	69.6	77.4			204	186
1923	92	21	117	6.6	58.0	67.3	77.2			163	129
1924	170	2	174	5.8	53.6	69.0	75.7			145	142
1925	210	0	210	2.0	55.2	71.4	79.1			207	207
1926	188	2	192	2.9	59.1	65.6	77.9			200	196
1927	178	3	184	5.1	61.4	66.5	77.3			189	183
1928	185	2	189	4.9	58.2	64.8	78.3			180	176
Sum	3,721		3,809	86.0	1,181.7	1,354.9	1,551.5				3,705
Mean	186		190	4.3	59.1	67.7	77.6				185

TABLE 1—Continued

LOUISIANA

Year	Yield (lbs. per acre)	Weevil data	Adjusted yield	Weather data (See text description)						Computed adjusted yield	Computed yield indices
				a	b	c	d	e	f		
	1	2	3	4	5	6	7	8	9	10	11
1914	165	18	201	8.4	74	19.6	70.1	------	------	207	170
1915	165	20	206	6.5	74	18.5	70.2	------	------	200	160
1916	170	24	224	11.7	71	17.7	72.2	------	------	208	158
1917	210	12	239	5.9	74	21.2	71.4	------	------	231	203
1918	167	10	186	9.1	66	20.0	68.4	------	------	175	157
1919	93	25	124	13.8	51	17.2	71.1	------	------	147	110
1920	126	26	170	9.1	71	17.8	71.0	------	------	196	145
1921	114	35	175	9.5	67	17.2	71.4	------	------	186	121
1922	144	25	192	11.1	65	17.4	69.4	------	------	164	123
1923	125	23	162	14.2	67	17.5	69.5	------	------	171	132
1924	145	5	153	9.2	74	17.6	68.7	------	------	179	170
1925	232	10	258	3.6	73	20.3	74.9	------	------	256	230
1926	200	9	220	11.9	76	20.0	69.9	------	------	214	195
1927	170	12	193	12.2	62	16.0	70.3	------	------	156	137
1928	165	17	199	10.8	70	16.4	72.3	------	------	197	164
Sum	2,391	------	2,902	147.0	1,035	274.4	1,060.8	------	------	------	2,375
Mean	159	------	193	9.8	69	18.3	70.7	------	------	------	158

ARKANSAS

1909	153	6	163	8	6.8	10	56	------	------	170	159
1910	175	7	189	9	6.6	10	66	------	------	189	176
1911	190	2	194	12	1.1	6	64	------	------	208	204
1912	190	2	194	12	2.4	9	62	------	------	192	188
1913	205	3	212	6	3.3	4	62	------	------	220	214
1914	196	3	203	9	3.3	2	55	------	------	196	190
1915	180	5	190	5	5.6	9	59	------	------	196	186
1916	209	7	225	7	3.6	8	58	------	------	198	185
1917	170	10	189	9	3.2	6	59	------	------	198	179
1918	158	3	163	9	3.0	7	44	------	------	165	159
1919	155	5	164	7	6.0	10	56	------	------	178	168
1920	195	9	215	9	8.2	6	64	------	------	184	167
1921	160	22	206	9	2.2	11	59	------	------	194	152
1922	173	18	211	9	5.1	7	65	------	------	200	166
1923	98	16	117	11	8.2	9	60	------	------	162	132
1924	169	4	177	8	4.6	8	48	------	------	168	160
1925	205	2	210	6	1.9	4	60	------	------	222	218
1926	195	3	202	7	2.4	6	58	------	------	208	202
1927	157	11	177	12	6.5	9	58	------	------	162	141
1928	161	15	191	9	3.6	13	62	------	------	190	162
Sum	3,494	------	3,792	173	87.6	154	1,175	------	------	------	3,508
Mean	175	------	190	9	4.4	8	59	------	------	------	175

OKLAHOMA

1909	147	3	152	24.0	80.1	44	------	------	------	140	136
1910	200	1	203	20.7	79.8	59	------	------	------	202	200
1911	160	0	160	23.9	82.4	51	------	------	------	161	161
1912	183	1	185	23.3	78.1	56	------	------	------	183	181
1913	132	0	132	23.4	79.9	34	------	------	------	109	109
1914	212	1	215	19.0	82.9	57	------	------	------	200	198
1915	162	3	168	21.9	76.4	64	------	------	------	217	211
1916	154	4	161	23.7	79.2	47	------	------	------	151	145
1917	165	4	172	22.5	80.0	57	------	------	------	188	180
1918	92	1	93	22.9	81.8	41	------	------	------	133	132
1919	195	1	197	18.8	78.1	52	------	------	------	189	187
1920	230	9	253	20.4	78.2	62	------	------	------	215	196
1921	104	41	177	22.4	78.7	53	------	------	------	177	104
1922	103	26	140	20.0	79.8	44	------	------	------	156	115
1923	98	19	121	21.0	80.2	41	------	------	------	142	115
1924	187	4	195	22.8	80.0	50	------	------	------	164	157
1925	155	2	159	21.3	83.1	50	------	------	------	167	164
1926	181	8	197	22.5	78.2	53	------	------	------	177	163
1927	138	31	200	23.6	78.0	62	------	------	------	202	139
1928	133	26	180	22.3	77.6	55	------	------	------	185	137
Sum	3,131	------	3,460	440.4	1,592.5	1,032	------	------	------	------	3,130
Mean	157	------	173	22.0	79.6	52	------	------	------	------	156

TABLE 1—Continued

TEXAS

Year	Yield (lbs. per acre)	Weevil data	Adjusted yield	Weather data (See text description)						Computed adjusted yield	Computed yield indices
				a	b	c	d	e	f		
	1	2	3	4	5	6	7	8	9	10	11
1909	125	12	144	3.4	74.7	3.1	70.0	52	20.3	152	133
1910	145	7	159	6.5	76.3	3.9	68.9	50	19.4	171	156
1911	186	1	192	7.7	73.9	2.1	72.1	58	19.9	173	167
1912	206	3	218	10.3	73.9	2.3	65.9	49	18.9	207	196
1913	150	7	169	8.1	75.4	2.6	68.6	49	21.3	160	142
1914	184	8	208	9.3	73.7	7.7	72.3	49	16.6	203	179
1915	147	16	184	9.2	72.9	2.5	70.4	52	18.0	204	164
1916	157	19	205	5.4	72.4	3.8	69.7	54	19.6	172	130
1917	135	7	158	3.6	74.4	2.8	68.9	46	19.6	163	140
1918	115	4	133	3.4	74.3	2.4	72.4	43	20.6	142	124
1919	140	14	178	11.4	74.3	5.3	66.9	62	19.1	203	162
1920	174	20	234	7.2	74.9	5.1	67.9	55	15.6	223	166
1921	98	34	166	7.6	73.9	1.9	69.6	56	20.1	176	105
1922	130	16	174	9.5	74.9	4.5	69.9	51	20.7	166	123
1923	147	10	183	10.0	74.4	2.0	70.4	51	19.6	186	149
1924	138	8	172	12.0	74.6	4.4	71.7	46	20.3	175	142
1925	113	2	139	4.3	80.3	2.6	72.4	47	19.5	147	122
1926	147	11	190	9.4	70.1	3.4	69.0	58	19.7	194	151
1927	129	20	186	9.6	79.1	1.6	69.1	53	20.3	172	118
1928	139	12	185	7.1	72.4	3.4	69.3	54	18.8	190	143
Sum	2,905	------	3,577	155.0	1,490.8	67.4	1,395.4	1,035	387.9	------	2,912
Mean	145	------	179	7.8	74.5	3.4	69.8	51.8	19.4	------	146

NOTE.—See context for description of data in Table 1.

COTTON ACREAGE HARVESTED (000 OMITTED)

TABLE 2

Year	North Carolina	South Carolina	Georgia	Alabama	Mississippi	Tennessee	Louisiana	Arkansas	Oklahoma	Texas	Total
1909	1,359	2,492	4,674	3,471	3,291	735	------	2,218	1,767	9,660	29,667
1910	1,478	2,534	4,873	3,560	3,317	765	------	2,238	2,204	10,060	31,029
1911	1,624	2,800	5,504	4,017	3,340	837	------	2,313	3,050	10,943	34,428
1912	1,545	2,695	5,335	3,730	2,889	783	------	1,991	2,665	11,338	32,971
1913	1,576	2,790	5,318	3,760	3,067	865	------	2,502	3,009	12,597	35,484
1914	1,527	2,861	5,433	4,007	3,054	915	1,299	2,480	2,847	11,931	36,354
1915	1,282	2,516	4,825	3,340	2,735	772	990	2,170	1,895	10,510	31,035
1916	1,451	2,780	5,277	3,225	3,110	887	1,250	2,600	2,562	11,400	34,542
1917	1,515	2,837	5,195	1,917	2,788	832	1,454	2,740	2,783	11,092	33,203
1918	1,600	3,001	5,341	2,570	3,138	902	1,683	2,991	2,998	11,233	35,457
1919	1,490	2,835	5,220	2,791	2,848	758	1,527	2,725	2,424	10,476	33,094
1920	1,587	2,964	4,900	2,858	2,950	840	1,470	2,980	2,749	11,898	35,196
1921	1,403	2,571	4,172	2,235	2,628	634	1,168	2,382	2,206	10,745	30,144
1922	1,625	1,912	3,418	2,771	3,014	985	1,140	2,799	2,915	11,874	32,453
1923	1,679	1,965	3,421	3,079	3,170	1,172	1,405	3,026	3,197	14,150	36,264
1924	2,005	2,404	3,046	3,055	2,981	996	1,616	3,094	3,861	17,175	40,233
1925	2,017	2,654	3,589	3,504	3,466	1,173	1,874	3,738	5,214	17,608	44,837
1926	1,985	2,648	3,965	3,651	3,752	1,143	1,979	3,790	4,676	18,374	45,963
1927	1,727	2,421	3,412	3,225	3,338	965	1,542	3,048	3,601	16,176	39,455
1928	1,890	2,355	3,719	3,595	3,994	1,086	1,985	3,610	4,249	17,766	44,249

PERCENTAGE OF TOTAL ACREAGE HARVESTED, BY STATES

TABLE 2 (a)

1909	4.6	8.4	15.7	11.7	11.1	2.5	------	7.5	6.0	32.5	------
1910	4.8	8.2	15.7	11.5	10.7	2.5	------	7.2	7.1	32.4	------
1911	4.7	8.1	16.1	11.7	9.7	2.5	------	6.7	8.9	31.8	------
1912	4.7	8.2	16.2	11.3	8.8	2.4	------	6.0	8.1	34.4	------
1913	4.5	7.9	15.0	10.6	8.7	2.4	------	7.0	8.5	35.5	------
1914	4.2	7.9	14.9	11.0	8.4	2.5	3.6	6.8	7.8	32.8	------
1915	4.1	8.1	15.5	10.8	8.8	2.5	3.2	7.0	6.1	33.9	------
1916	4.2	8.0	15.3	9.3	9.0	2.6	3.6	7.5	7.4	33.0	------
1917	4.6	8.5	15.6	5.8	8.4	2.7	4.4	8.2	8.4	33.4	------
1918	4.5	8.5	15.1	7.2	8.9	2.5	4.7	8.4	8.5	31.7	------
1919	4.5	8.6	15.8	8.4	8.6	2.3	4.6	8.2	7.3	31.7	------
1920	4.5	8.4	13.9	8.1	8.4	2.4	4.2	8.5	7.8	33.8	------
1921	4.7	8.5	13.8	7.4	8.7	2.1	3.9	7.9	7.3	35.6	------
1922	5.0	5.9	10.5	8.5	9.3	3.0	3.5	8.6	9.0	36.6	------
1923	4.6	5.4	9.4	8.5	8.7	3.2	3.9	8.3	8.8	39.0	------
1924	5.0	6.0	7.6	7.6	7.4	2.5	4.0	7.7	9.6	42.7	------
1925	4.5	5.9	8.0	7.8	7.7	2.6	4.2	8.3	11.6	39.3	------
1926	4.3	5.8	8.6	7.9	8.2	2.5	4.3	8.2	10.2	40.0	------
1927	4.4	6.1	8.6	8.2	8.5	2.4	3.9	7.7	9.1	41.0	------
1928	4.3	5.3	8.4	8.1	9.0	2.5	4.5	8.2	9.6	40.1	------

TABLE 3

COMPUTED YIELD INDICES
(See column 11, Table 1)

Year	North Carolina	South Carolina	Georgia	Alabama	Mississippi	Tennessee	Louisiana	Arkansas	Oklahoma	Texas	Average
1909	226	211	172	156	174	168	------	159	136	133	160
1910	222	211	165	159	173	162	------	176	200	156	172
1911	311	244	219	190	179	218	------	204	161	167	196
1912	254	226	170	175	157	192	------	188	181	196	190
1913	254	215	211	181	159	210	------	214	109	142	173
1914	302	250	229	200	201	227	170	190	198	179	204
1915	285	248	201	143	173	180	160	186	211	164	185
1916	228	162	178	84	141	191	158	185	145	130	148
1917	207	213	176	138	192	158	203	179	180	140	169
1918	267	228	184	166	193	197	157	159	132	124	165
1919	265	196	126	109	158	182	110	168	187	162	160
1920	259	235	123	110	123	185	145	167	196	166	164
1921	262	161	102	131	168	216	121	152	104	105	132
1922	215	122	95	129	150	186	123	166	115	123	133
1923	263	185	93	100	106	129	132	132	115	149	137
1924	206	168	150	164	212	142	170	160	157	142	158
1925	282	165	188	201	260	207	240	218	164	122	173
1926	294	217	189	172	220	196	195	202	163	151	180
1927	236	146	157	172	192	183	137	141	139	118	145
1928	194	185	141	144	168	176	164	162	137	143	152

NOTE.—Average obtained by weighting on basis of percentages in Table 2 (a).

TABLE 4

Year	1	2	3	4	Year	1	2	3	4
1909	29,667	160	9,930	9,641	1921	30,144	132	8,324	7,768
1910	31,029	172	11,165	11,219	1922	32,453	133	9,030	9,467
1911	34,428	196	14,117	15,081	1923	36,264	137	10,394	9,781
1912	32,971	190	13,106	13,183	1924	40,233	158	13,299	13,119
1913	35,484	173	12,843	13,531	1925	44,837	173	16,228	15,382
1914	36,354	204	15,515	15,883	1926	45,963	180	17,308	17,332
1915	31,035	185	12,011	11,044	1927	39,455	145	11,969	12,533
1916	34,542	148	10,695	11,262	1928	44,249	152	14,071	13,856
1917	33,203	169	11,739	11,101					
1918	35,457	165	12,239	11,796	Sum	716,058	3,296	247,136	247,305
1919	33,094	160	11,077	11,197	Mean	35,803	165	12,357	12,365
1920	35,196	164	12,076	13,129					

Column 1.—Total acreage for 10 States. (000 omitted. See final column Table 2.)
Column 2.—Computed average yield per acre for 10 States. (See final column, Table 3.)
Column 3.—Computed production for 10 States, in 500-pound gross weight bales (478 pounds net — 000 omitted).
Column 4.—Production for 10 States, in 500-pound gross weight bales (000 omitted).

NOTE.—The correlation coefficient between columns 3 and 4 (computed production for the 10 States and actual production) is +0.97.

Table 1 contains the basic data used in all computations for the States of North Carolina, South Carolina, Georgia, Alabama, Mississippi, Tennessee, Louisiana, Arkansas, Oklahoma, and Texas. Column 1 of the table shows the per-acre yield of cotton for the 10 respective States as reported by the Department of Agriculture. Column 2 contains the weevil indices, expressed in percentages of reduction in yield, as similarly reported; these represent the estimated percentage reduction by weevil from a full yield of cotton. Column 3, shows an adjusted yield, or the approximate yield that would have obtained without weevil damage, and, obviously, are data directly related to the varying weather from year to year. They are obtained by the equation $\bar{Y}=\frac{y}{1-w}$, where "$\bar{Y}$" is the adjusted yield (column 3), "y" the yield (column 1) and "w" the weevil indices in percentages of yield reduction (column 2). These data are the best indications obtainable of what the yield would have been from year to year without loss from weevil. Columns 4 to 9 contain the various weather data used in the correlations for the several States, as indicated hereinafter for each. Column 10 shows the computed adjusted yield indices determined by multiple correlations and regression equations based on the relation of the weather data to the adjusted yields in column 3. The adjusted yields are used as the basic yield data because of their direct relation to the weather conditions with weevil damage eliminated. Column 11 shows the final computed yield indices for the respective States, obtained by the equation $\bar{Y}=y-yw$ where "$\bar{Y}$" is the computed yield (column 11); "y" the computed adjusted yield (column 10), and "w" the percentage weevil data (column 2).

Next, we reduce the final computed yield indices (column 11 Table 1; also Table 3) for the several States, to a unit or average per-acre yield for the entire area of 10 States, by weighting on an acreage-percentage basis. That is, we determine the percentage of the total acreage for all States that is represented by the acreage of the individual States, and apply these to the respective computed acreage yield indices, shown in column 10 of Table 1, and in Table 3.

Table 2 shows the acreage (000 omitted) of cotton harvested for the several States, for each of the 20 years, while Table 2a gives the percentage of the total accounted for by each State, as explained in the preceding paragraph. Table 3 contains a tabulation of the computed per-acre

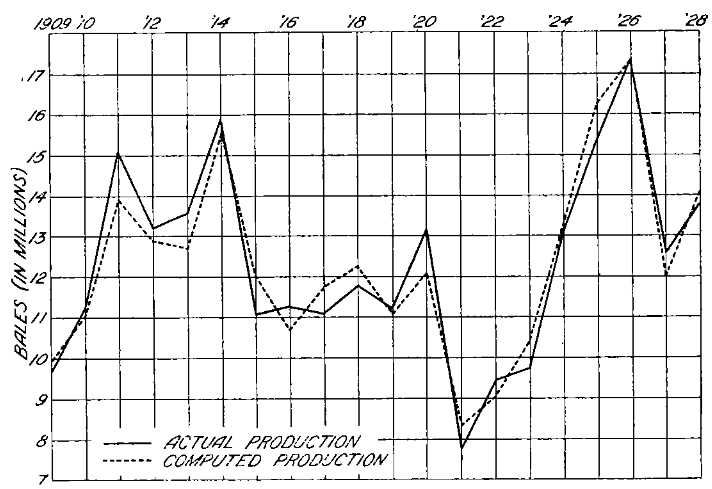

FIGURE 1.—Showing graphic relation between the production of cotton in the 10 principal producing States and the computed production from weather records—production in bales of 500 pounds, gross weight

yield indices, shown in column 11 of Table 1, for the respective States, the final column giving the average computed per-acre yield for the entire area, obtained by weighting on the percentage basis as above.

Finally, Table 4 shows, in column 1, the total acreage for the 10 States for each of the 20 years; column 2, the computed average yield per acre (final column in Table 3); column 3, the computed 500-pound gross weight bales (478 pounds net), and column 4 the total production in bales for the 10 States. The correlation coefficient between columns 3 and 4, or the computed production and actual production, is +0.97. A graphic relation is shown in Figure 1.

THE WEATHER DATA AND COMPUTATIONS

The weather data used, as hereinafter indicated for the several States, are monthly rainfall, number of rainy days, monthly mean temperature, percentage of sunshine, post meridian relative humidity, mean maximum temperature, mean minimum temperature, and the average daily range of temperature. For the rainfall data, number of rainy days, and monthly mean temperature, records for all stations of the Weather Bureau maintained in the respective States were included, about 600 in all, and for sunshine, post meridian relative humidity, maximum and minimum temperatures, and daily temperature range, those for first-order stations within and on the border of the respective States were generally used, as later indicated. The relative humidity data are the monthly means of the observations made at 8 p. m., seventy-fifth meridian time, which corresponds to 7 p. m. local time in most of the Cotton Belt. The sunshine data are the mean monthly percentages of the possible amount.

Details for the several States are as follows:

North Carolina.—The weather data used are: (*a*) May rainfall; (*b*) June rainfall; (*c*) July sunshine; and (*d*) September rainfall. The first-order station data are the means for Charlotte, Raleigh, and Wilmington, N. C., and Norfolk, Va. The details of computations for North Carolina are shown in the following equations; those for the other States are similar:

The correlations and regressions for North Carolina:

$$R^2 = \beta xa \cdot rax + \beta xb \cdot rbx + \beta xc \cdot rcx + \beta xd \cdot rdx \tag{1}$$

Equation for computing the betas:

$$\left.\begin{aligned} \beta xa + rab\cdot\beta xb + rac\cdot\beta xc + rad\cdot\beta xd &= rax \\ rab\cdot\beta xa + \beta xb + rbc\cdot\beta xc + rbd\cdot\beta xd &= rbx \\ rac\cdot\beta xa + rbc\cdot\beta xb + \beta xc + rcd\cdot\beta xd &= rcx \\ rad\cdot\beta xa + rbd\cdot\beta xb + rcd\cdot\beta xc + \beta xd &= rdx \end{aligned}\right\} \tag{2}$$

Coefficients of correlations:

$$\begin{gathered} rax = -0.46;\ rbx - 0.76;\ rcx + 0.54;\ rdx - 0.46 \\ rab = +0.50;\ rac - 0.19;\ rad + 0.20 \\ rbc = -0.37;\ rbd + 0.11 \\ rcd = -0.08 \end{gathered}$$

σa, 1.43; σb, 1.46; σc, 4.51; σd, 2.67; and σx, 36.59

Solving (2), with coefficients substituted, gives:

$$\beta xa - 0.034;\ \beta xb - 0.598;\ \beta xc + 0.283;\ \beta xd - 0.365$$

The regression equation:

$$\begin{aligned} \overline{X} = M_X + \beta xa\frac{\sigma x}{\sigma a}(A - M_A) + \beta xb\frac{\sigma x}{\sigma b}(B - M_B \\ + \beta xc\frac{\sigma x}{\sigma c}(C - M_C) + \beta xd\frac{\sigma x}{\sigma d}(D - M_D) \end{aligned} \tag{3}$$

Where $\overline{X}$ is the North Carolina computed, adjusted per-acre yield indices; X, the adjusted per-acre yield of cotton. (Table 1, column 3.) A, B, C, and D the respective weather data, and M_A, M_B, M_C, and M_D their means; all as shown in Table 1.

Substituting the proper data in Table 1 and those obtained from equation 2 and solving 3, gives the following.

$$\overline{X} = -0.87A - 14.99B + 2.30C - 5.00D + 210.3 \tag{4}$$

South Carolina.—The weather data used are: (*a*) Number of rainy days in June: (*b*) July rainfall; and (*c*) August post meridian relative humidity.

First-order station data for Augusta, Ga., Charlotte, N. C., and Charleston, Columbia, and Greenville, S. C. The correlation coefficients are, *rax* − 0.43; *rbx* − 0.43; and *rcx* + 0.41, with intercoefficients, *rab* + 0.23; *rac* + 0.06; and *rbc* + 0.14. The standard deviations are, *a*, 2.20; *b*, 2.42; *c*, 4.77; and *x*, 34.72. The betas, *a*, −0.364; *b*, −0.415; and *c*, + 0.490. The constants, −5.74*A*; −5.96*B*; +3.57*C*; +48.4.

Georgia.—The weather data used are: (*a*) May mean maximum temperature; (*b*) June mean daily temperature range; and (*c*), total rainfall May to July, inclusive. First-order station data for Atlanta, Augusta, Macon and Thomasville. The correlation coefficients, *rax* + 0.49; *rbx* + 0.69; *rcx* − 0.61, with intercoefficients, *rab* + 0.27; *rac* − 0.05; *rbc* − 0.71. The standard deviations, *a*, 2.46; *b*, 1.52; *c*, 3.51, and *x*, 25.87. The betas, *a*, +0.381; *b*, +0.338; and *c*, +0.352. The constants, +4.01*A*; +5.75*B*; −2.59*C*; −218.5.

Alabama.—The weather data used are: (*a*) April mean temperature; (*b*) May rainfall; (*c*) June sunshine; and (*d*) July rainfall. First-order station data for Chattanooga, Tenn., Birmingham and Mobile, Ala., and Meridian, Miss. The correlation coefficients, *rax* + 0.37; *rbx* − 0.57; *rcx* + 0.40; *rdx* − 0.60, with intercoefficients, *rab* + 0.03; *rac* ± 0.00; *rad* − 0.24; *rbc* − 0.33; *rbd* + 0.06; *rcd* − 0.10. The standard deviations, *a*, 2.15; *b*, 1.90; *c*, 7.75; *d*, 2.67, and *x*, 26.17. The betas, *a*, +0.268; *b*, −0.486; *c*, +0.191; and *d*, −0.488. The constants, +3.26*A*; −6.69*B*; +0.65*C*; −4.78*D*; −18.6.

Mississippi.—The weather data used are: (*a*) April rainfall; (*b*) May rainfall; (*c*) June rainfall; and (*d*) July mean temperature. All data are State means. The correlation coefficients, *rax* − 0.45; *rbx* − 0.47; *rcx* − 0.49; *rdx* + 0.44, with intercoefficients *rab* − 0.08; *rac* + 0.33; *rad* − 0.25; *rbc* + 0.43; *rbd* − 0.08; *rcd* − 0.15. The standard deviations, *a*, 2.72; *b*, 2.39; *c*, 1.67; *d*, 1.01; and *x*, 38.43. The betas, *a*, −0.359; *b*, −0.407; *c*, −0.152; and *d*, +0.295. The constants, −5.07*A*; −6.54*B*; −3.50*C*; +11.22*D*; −616.4.

Tennessee.—The weather data used are: (*a*) May rainfall; (*b*) May mean minimum temperature; (*c*) June mean minimum temperature; and (*d*) July mean temperature. First-order station data for Cairo, Ill., and Memphis and Nashville, Tenn. The correlation coefficients, *rax* − 0.52; *rbx* + 0.41; *rcx* + 0.36; and *rdx* + 0.38, with intercoefficients, *rab* − 0.09; *rac* − 0.35; *rad* − 0.23; *rbc* + 0.05; *rbd* − 0.01; *rcd* + 0.29. Standard deviations, *a*, 1.45; *b*, 2.73; *c*, 2.45; *d*, 1.42; and *x*, 31.73. The betas, *a*, −0.381; *b*, +0.372; *c*, +0.133; and d, +0.257. The constants, −8.34*A*; +4.32*B*; +1.72*C*, +5.74*D*; −591.9.

Louisiana.—The weather data used are: (*a*) Rainfall for April and May combined; (*b*) June sunshine; (*c*) June mean daily temperature range; and (*d*) July mean minimum temperature. First-order station data New Orleans and Vicksburg for sunshine, and Alexandria, Minden, and Monroe for daily temperature range and mean minimum temperature; for rainfall the State means were used. Shreveport was not used for sunshine data because these are not readily available for that station, while the records for Alexandria, Minden, and Monroe were employed in the case of temperature, because these stations represent the cotton-growing sections of Louisiana better than do Vicksburg and New Orleans; sunshine data are not available for Alexandria, Minden, and Monroe. In the case of Louisiana, only 15 years record, from 1914 to 1928, inclusive, were used, because the available early weevil data for that State appear out of harmony with other States, and also with weather records, especially for the years 1909 and 1910 for which the estimated weevil damage is reported as 42 and 40 per cent, respectively, with the next highest figures 14 per cent for Texas and 15 per cent for Mississippi.

The correlation coefficients for Louisiana are: $rax-0.63$; $rbx+0.64$; $rcx+0.59$; $rdx+0.53$, with intercoefficients, $rab-0.58$; $rac-0.63$; $rad-0.41$; $rbc+0.52$; $rbd+0.09$; $rcd+0.10$. The standard deviations, a, 2.83; b, 6.22; c, 1.50; d, 1.58; and x, 33.19. The betas, a, +0.026; b, +0.441; c, +0.330; and d, +0.468. The constants, $+0.305A$; $+2.35B$; $+7.30C$; $+9.83D$; -801.3.

Arkansas.—The weather data used are: (*a*) Number of rainy days in April; (*b*) May rainfall; (*c*) number of rainy days in June; and (*d*) July post meridian relative humidity. First-order station data for Fort Smith and Little Rock, Ark., Memphis, Tenn., and Shreveport, La. Correlation coefficients, $rax-0.30$; $rbx-0.46$; $rcx-0.36$; and $rdx+0.36$; with intercoefficients, $rab+0.05$; $rac+0.19$; $rad+0.17$; $rbc+0.31$; $rbd+0.11$; $rcd+0.07$. The standard deviations, a, 1.99; b, 2.07; c, 2.61; d, 5.23; and x, 24.06. The betas, a, -0.322; b, -0.435; c, -0.197; and d, $+0.476$. The constants, $-3.90A$; $-5.05B$; $-1.82C$; $+2.19D$; $+131.4$.

Oklahoma.—The weather data used are: (*a*) Mean daily temperature range in May; (*b*) mean temperature for June and July, combined; and (*c*) post meridian relative humidity for August. First-order station data for Oklahoma City, Okla., Amarillo, Tex., and Fort Smith, Ark. The correlation coefficients, $rax-0.33$; $rbx-0.33$; and $rcx+0.78$, with intercoefficients, $rab-0.07$; $rac-0.21$; $rbc-0.41$. The standard deviations, a, 1.55; b, 1.78; c, 7.74; and x, 34.99. The betas, a, -0.181; b, -0.047; c, $+0.723$. The constants, $-4.09A$; $-0.92B$; $+3.27C$; $+167.8$.

Texas.—The weather data used are: (*a*) Rainfall, December to March, inclusive; (*b*) April mean maximum temperature; (*c*) May rainfall; (*d*) June mean minimum temperature; (*e*) July post meridian relative humidity; and (*f*) mean daily temperature range in August. Texas is the only State in which antecedent rainfall shows a significant relation to the yield of cotton. First-order station data are for Abilene, Amarillo, Fort Worth, Galveston, Palestine, San Antonio, Tex., and Shreveport, La. The correlation coefficients, $rax+0.51$; $rbx-0.36$; $rcx+0.35$; $rdx-0.41$; $rex+0.42$; $rfx-0.65$, with intercoefficients, $rab-0.17$; $rac+0.24$; $rad-0.27$; $rae+0.35$; $raf-0.11$; $rbc-0.20$; $rbd+0.16$; $rbe-0.35$; $rbf+0.16$; $rcd+0.04$; $rce+0.09$; $rcf-0.57$; $rde-0.39$; $rdf+0.12$; $ref-0.18$. The standard deviations, a, 2.56; b, 2.14; c, 1.44; d, 1.75; e, 4.57; f, 1.32; and x, 25.10. The betas, a, +0.372; b, -0.174; c, -0.120; d, -0.180; e +0.057; and f, -0.618. The constants, $+3.65A$; $-2.04B$; $-2.09C$; $-2.58D$; $+0.31E$; $-11.75F$; $+701.7$.

In Texas, there was found, after the usual adjustment of yield on the basis of weevil damage, a very definite diminishing trend in per-acre yield, due, most likely, to the marked expansion in acreage westward and northwestward in sections less productive from a per-acre-yield standpoint. Before applying the correlations of weather data to the adjusted yields, as in the other cases, it was found necessary to include this trend in the adjustment, and, therefore the data in column 3, Table 1, for this State, were obtained by first adjusting the yield for weevil as in the other cases, then for trend in the usual way for trend elimination. The trend was found to be -1.34; that is an average yearly decrease in per-acre yield by this amount, and the accumulations were added for the respective years of the series. The accumulated amounts for the trend adjustments were as follows: 1909—1 pound per acre; 1910—3; 1911—4; 1912—5; 1913—7; 1914—8; 1915—9; 1916—11; 1917—12; 1918—13; 1919—15; 1920—16; 1921—17; 1922—19; 1923—20; 1924—21; 1925—23; 1926—24; 1927—25; and 1928—27. The computed, adjusted yields for Texas, column 10, Table 1, for the several years, include these trend values and they are, therefore, deducted before and in addition to the weevil adjustment to obtain the finally computed yield in column 11. Apparently this 20-year period covers the trend tendency and, consequently, in applying the data to future years the last figure, that is, 27 pounds per acre, may be considered a constant.

THE WEATHER-WEEVIL INDICES

Reference has been made to a paper published in the MONTHLY WEATHER REVIEW in August, 1928, entitled "Weather and the Cotton Boll Weevil," and to the fact that this study was the first step in the present investigation, and forms a part of it. It has been found desirable, however, to revise that paper in certain respects, so that advantage could be taken of the data that have become available since its preparation, and also to make the time element comparable, in all cases, to the period of the growing season covered by the subsequent study, as before outlined. The former records ended with 1927, and, in some cases, weather data for months later than August were used. The revision involves weather data only through the month of August in all cases, which permits the determination of a weevil index for the several States coincident with the computations of weather and cotton production, as heretofore outlined.

It has been shown that there are three distinct weather phases which, in conjunction, constitute a natural weevil control, and consequently, determine very largely the amount of damage by weevil from year to year. The weather phases bearing on weevil damage for a given year include: (*a*) Conditions during the preceding growing season, as affecting the number of insects present at its close and going into winter hibernation; (*b*) the severity of the winter, with relation to mortality in hibernation, which has a bearing on the number emerging in spring; and (*c*) the weather as affecting propagation and activity during the current growing season.

The indices for the number of weevil going into hibernation were originally computed from the preceding growing season's weather, but in the revision the percentage of damage done by weevil during the preceding summer has been substituted. Evidently, the amount of weevil damage must have a very definite relation to the number present, and this affords a much simpler and very convenient index for the first phase of the problem. For the second phase—index for deaths in hibernation—records of the lowest temperature reached during the winter, as in the original paper, have been retained; and also the prevailing weather during the growing season for the final phase, but with some slight modifications to afford synchronization, as before indicated. In addition to the above, regression constants have been established for computing weevil indices for the States of North Carolina, South Carolina, and Tennessee, not included in the original paper. These latter, because of the comparatively few years of weevil presence, are naturally less dependable than for those States with longer periods of weevil activity.

For the revised weevil index determinations, the following data were used for each of the 10 States: (*a*) The percentage of damage by weevil, for the preceding year (see column 2, Table 1); (*b*) minimum temperature during the preceding winter, represented by the average of the lowest recorded during the winter at first-order stations within or near the border of the respective States, as indicated below; and (c) the growing season weather data, as hereafter named, for the respective States. For phase (c), data relating to rainfall, number of cloudy days and number of rainy days are respective State means for all Weather Bureau stations maintained in the respective States, while the sunshine and relative humidity data are for the first-order stations named for each State. The relative humidity data are the means for the noon and post meridian observations. In the following summary the details of computations are omitted and only the constants applicable to the several phases for computing the weevil indices given:

DATA USED FOR REVISED WEATHER-WEEVIL COMPUTATION

(The *a* and *b* phases are the same for all States, as before indicated)

North Carolina.—Weather data (*c*) percentage of possible sunshine, June to August, inclusive. First-order stations Charlotte, Raleigh, and Wilmington, N. C., and Norfolk, Va. The constants, $+0.25b$; $-1.53c$; $+10.9$. (Phase "*a*" not used, because of shortness of record.)

South Carolina.—Weather data (*c*) percentage of possible sunshine, July and August, combined. First-order stations Charleston, Columbia, and Greenville, S. C., Augusta, Ga., and Charlotte, N. C. The constants, $+0.20a$; $+0.67b$; $-1.41c$; $+99.0$.

Georgia.—Weather data (*c*) relative humidity July and August, combined. First-order stations Atlanta, Augusta, Macon, and Thomasville, Ga. The constants, $+0.44a$; $+1.35b$; $+1.88c$; -132.9.

Alabama.—Weather data (*c*) relative humidity, July and August, combined, and (c_1) August rainfall. First-order stations, Birmingham and Montgomery, Ala., and Meridian, Miss. The constants, $+0.46a$; $+0.57b$; $+0.99c$; $+1.28c_1$; -66.1.

Mississippi.—Weather data (*c*) number of cloudy days, April to August, inclusive; (c_1) relative humidity, July and August, combined. First-order stations Meridian and Vicksburg, Miss., and Memphis, Tenn. The constants, $+0.24a$; $+0.51b$; $+0.38c$; $+0.75c_1$; -52.4.

Tennessee.—Weather data (*c*) rainfall July and August, combined. First-order stations Memphis and Nashville, Tenn., and Cairo, Ill. The constants, $+0.52a$; $+0.62b$; $+0.88c$; -41.1.

Louisiana.—Weather data (*c*) rainfall June and July, combined; (c_1) relative humidity, June to August, inclusive. First-order stations Shreveport, La., and Vicksburg, Miss. The constants, $+0.30a$; $+0.19b$; $+1.14c$; $+0.39c_1$; -27.3.

Arkansas.—Weather data (*c*) number of rainy days, June and July, combined. First-order stations Fort Smith and Little Rock, Ark., and Memphis, Tenn. The constants, $+0.43a$; $+0.40b$; $+1.27c$; -16.5.

Oklahoma.—Weather data (*c*) rainfall, June and July, combined. First-order stations Oklahoma City, Okla., and Fort Smith, Ark. The constants, $+0.32a$; $+0.63b$; $+4.48c$; -25.2.

Texas.—Weather data (*c*) rainfall, June and July combined; (c_1) relative humidity, June to August, inclusive. First-order stations Abilene, Amarillo, Fort Worth, Palestine, San Antonio, and Taylor, Tex., and Shreveport, La. The constants, $+0.31a$; $+0.75b$; $+1.19c$; $+0.32c_1$; -23.8.

CONCLUSIONS

In the matter of application of the results of this study to future years for an early indication of cotton production, it may be pointed out that practically all data are available soon after the close of August for a current growing season. The compilations in full, including the combined weather-weevil determinations, and the weather-yield correlations for the 10 States, comprise some 75 independent variants, covered into the final results through 20 separate equations, but only 1 contains more than 4 variants. None of the data, except September rainfall in North Carolina, extends later in the season than August.

In case application of results is desired before the North Carolina September rainfall becomes available, this may be approximated by using the average rainfall for that month. In such case, because of the large number of variants used, the error would be negligible, as a rule. For example, by using the North Carolina average September rainfall, instead of the actual, for the 20-year period covered by this study, the results would differ from those obtained by using the actual rainfall by an average of less than 0.3 of 1 per cent, with a maximum difference of only 1 per cent, notwithstanding September rainfall in North Carolina varied during the period from 1.2 inches to 11.2 inches. This is a striking indication that the methods used in these computations give a stability in results much greater than is usually found in weather-crop correlation work, which inspires confidence as to its satisfactory future application.

Acknowledgment is hereby made of the valuable cooperation given in this study by Mr. W. A. Mattice, who assisted in computing the many correlations required, and by Miss G. B. Diehl, in compilation and computation of necessary data.

METEOROLOGY AND ITS IMPORTANCE TO AVIATION

By W. J. HUMPHREYS

Some knowledge of the air and its ways obviously is essential to both the science and the art of aerial navigation. It does not follow, however, that all who are concerned with this science and this art need to know exactly the same things about the atmosphere, nor to know them in exactly the same way. The designer of the engine must know the composition and density of the atmosphere at all levels at which the machine is supposed to operate, since these are essential factors in the determination of the power available, but he does not need to know much about the theory of turbulence, skin friction, stream lines, and the like. These vitally important matters concern, most of all, the designers of the wings and the fuselage. Finally the aviator, though his very life depends on somebody's knowledge of these things, does not often himself bother about them. He would be bored beyond endurance by the exact observations, experiments, "high-brow" theories, and tedious calculations they require. His is the active, impatient spirit that wants to be up and flying. He would rather fly a "barn door" right away than hang around a month or two waiting for the finest product the laboratories can produce. Neither does he care to know, nor much need to know, the technical terms and long equations which the meteorologist uses in his discussions of wind and weather. He takes his machine,